

ART. VIII.—*On the Presence of Ciliated Pits in
Australian Land Planarians.*

(With Plate V.)

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In his well known memoir, "On the Anatomy and Histology of the Land Planarians of Ceylon,"* Professor Moseley describes the presence of ciliated pits on the anterior margin of the head of *Bipalium*. As his remarks on these pits are short, and at the same time of great interest. I may perhaps be allowed to quote them in full:—"In describing the habits of *Bipalium*, I described the manner in which the animal throws out tentacular-like projections from the anterior margin of its semi-lunar head when in motion, and evidently uses these temporary tentacles as sense organs. In reading M. Humbert's interesting account of *Bipalium*, I found that he had observed this habit of the animal as well as I, and had been led by his observation to seek for sense-organs or tentacular structures on the margin of the head. He was not successful in finding any; but on very careful examination of well-hardened specimens I was more fortunate, and discovered a narrow band extending along the whole anterior margin of the head, entirely free from pigment, and occupied by a row of cylindrical rounded papillæ placed vertically side by side, and with small oval openings between their superior extremities (Plate XIII, Fig. 16). This row of papillæ is in the upper part of the lower fifth of the margin of the head, so that it lies close to the ground when the animal's head is lowered. The papillæ are covered with short cilia, but I could find no special structure in them, except that in their region, and that of the ciliated pits, there

* Philosophical Transactions of the Royal Society, 1874.

is a large quantity of tissue formed of small spindle-cells. The oval apertures between the papillæ lead to ciliated pits, the appearance presented by which is shown in Figs. 11, 12, and 13, Plate XV. In longitudinal and horizontal sections, the appearance presented in Fig. 13 is seen. The light bands, which appear to pass to the bottoms of the ciliated pits, are continuous with the vascular* network of the head. Whether they represent tubes in communication here with the exterior, I cannot say. They may convey nerves to the sacs. From the manner in which the animal uses the front of its head, there can be little doubt that the papillary line discharges some special sense-function; but it is possible that this function is discharged by the papillæ, whilst the ciliated pits, with their communicating vascular stems act as excretory organs. The papillary line, with its pits, was found in all the species of *Bipalium* examined. The ciliated sacs of Nemertines came at once, of course, into one's mind in connection with these curious structures. Careful examination may perhaps give evidence of the existence of similar ciliated sacs in *Geoplana* and other Planarians. Nothing of the kind was found in *Rhynchodemus*."

Although Professor Moseley subsequently studied and described† species of *Geoplana* from New South Wales and elsewhere, he failed to discover the presence in them of ciliated pits. Von Kennel, also, makes no mention of them in the German land Planarians belonging to the genera *Rhynchodemus* and *Geodesmus*, which were carefully investigated by him,‡ nor have they hitherto been discovered by any of the Australian zoologists who have more recently paid attention to the group. In my memoir on "The Anatomy of an Australian Land Planarian," published in the Transactions of this Society for 1889, no mention is made of any such organs, nor did I at that time suspect their existence, so that, so far, the memoir is incomplete, and I am glad of the present opportunity of making up the deficiency.

The object of the present communication, therefore, is to record the occurrence and describe the structure and arrangement of ciliated pits in Australian land Planarians belonging to the genera *Geoplana* and *Rhynchodemus*. It

* This is now known to be a nervous, and not a vascular, structure.—A. D.

† "Notes on the Structure of Several Forms of Land Planarians, &c." *Quarterly Journal of Microscopical Science*, Vol. XVII (N.S.), p. 273.

‡ "Die in Deutschland gefundenen Landplanarien, &c." *Arbeiten des Zool.—Zoot. Institut in Würzburg*, Band V, Heft 2.

seems strange that these have not been discovered before, but they are of extremely minute size, invisible with a pocket lens, while even under a low power of the microscope their true nature is difficult to make out; when, however, they are examined under certain favourable conditions, which will be described presently, they are very clearly visible indeed.

The following is a list of the species in which I have found them:—*Geoplana spenceri*, *G. alba*, *G. ventrolineata*, *G. munda*, *G. ventropunctata*, *G. quinquelineata*, *G. hoggi*, *G. adae*, *G. caerulea* (blue-tipped variety), *G. dendyi*, *G. quadrangulata* var. *wellingtoni*, *G. sugdeni*, *G. fletcheri*, *G. howitti* var. *obsoleta*, *G. mediolineata*, *G. m'mahoni*, and *Rhynchodemus similans*.

Of these species I have examined the ciliated pits in the living state only in *Geoplana ventrolineata*, *G. alba* and *G. caerulea* (blue-tipped variety). In the other species I have clearly recognised them in spirit-preserved specimens. In short, I believe that the ciliated pits occur in all species of *Geoplana* and *Rhynchodemus*.

I first noticed the pits in examining some spirit-preserved specimens of *Geoplana ventrolineata* as opaque objects under a low power of the microscope. I found on the ventral surface, at each side of the anterior extremity, a light longitudinal line, devoid of pigment, slightly curved as shown in Fig. 6, and apparently slightly raised as a ridge, but this raised effect was doubtless exaggerated by the disposition of the pigment, for hardly any ridge is visible in transverse sections (Fig. 7). This line lies beneath the line of eyes, and obviously corresponds to the margin of the horse-shoe-shaped anterior extremity in the living animal. Along the inner margin of the light line on each side was visible a single row of very minute dark specks, which proved on careful examination to be minute punctuations like those made by the point of a very fine needle. These punctuations are arranged with great regularity, and extend throughout the entire length of the light line, disappearing as the latter dies out posteriorly. I could not determine whether or not the punctuations were continued all round the anterior margin; they are only clearly visible in a good light, and it is possible that I may have overlooked them in front.

Having satisfied myself as to the presence of the line of pits in *G. ventrolineata* I went through my collection and examined all the other species I had under similar conditions.

In nearly every species I saw the row of pits clearly; always situate in a light line on each side of the ventral aspect of the head, beneath the line of eyes. Generally the pits have the form of well-defined though minute perforations, as in *G. ventrolinosa*. In some of the species, however, and notably in *G. spenceri* (Fig. 8) the light line (= margin of horse-shoe-shaped anterior extremity) tends to become grooved or furrowed transversely: the pits in this case lie in the transverse grooves, very much as figured by Moseley for *Bipedium*. In *G. spenceri* the transverse furrows are well marked in large specimens and may be connected by a longitudinal furrow as shown in Fig. 8. Such furrows might easily be mistaken for artificial wrinkling due to the action of the spirit, and, had it not been for comparison with other specimens, I should not have suspected the presence of ciliated pits in *G. spenceri*.

At this stage in the investigation I received from Mr H. Grayson living specimens of *G. caerulea* (blue-tipped variety), *G. alba* and *G. ventrolinosa*, captured in Brunnings' Nursery Garden at St. Kilda. Microscopic examination of these soon showed the true nature of the pits seen in spirit-preserved specimens. In making such an examination of living material I find it best to proceed as follows.—Cut off the anterior end of the Planarian with a sharp scalpel, lay it in a drop of water on a glass slip with the ventral surface uppermost; put a cover glass over it and then, with a few sharp raps on the cover glass with a pencil or other blunt instrument, flatten out and crush the specimen until it becomes sufficiently transparent. On examining such a preparation of the blue-tipped variety of *G. caerulea* with a low power of the microscope Zeiss A. oc. 2, and by transmitted light, I saw the appearance represented in Fig. 1. The eyes (*e.*) were arranged in single series all round the anterior extremity. Inside the line of eyes and separated from it by a narrow interval was visible the light line (*l. l.*) corresponding to the margin of the horse-shoe-shaped anterior extremity of the living animal. In this line was visible the single row of ciliated pits (*c. p.*), apparently not continuous round the front, though on this point I am doubtful. Of these pits there seemed to be about thirty on each side. A much higher power, such as Zeiss D or F, is necessary in order to make out the structure of the pits, which measure only about 0.017 mm. in outside transverse diameter.

Under a high power the pits are seen to be oval or circular in optical transverse section, with a very characteristic sharp double outline (Figs. 3 and 5), the thick wall of the pit being composed of almost cubical cells arranged in a circle. These cells in *G. caerulea* are slightly granular, and richly ciliated, resembling, in fact, the ordinary epidermic cells of the ventral surface as described by me in *Geoplana zoenveri*.* In *G. caerulea* the cilia appear, as far as can be seen by focussing at different levels, to be continuous right to the bottom of the pit, while the pits themselves appear deep and dilated below. The cilia in the pits work in a spiral or vortex. The whole ventral surface of the animal, of course, also appeared ciliated. Occasionally the wall of the pit is seen to contract suddenly and spasmodically, but this only happens rarely and with no regularity.

The observations made upon living specimens of *Geoplana caerulea* were confirmed in the case of *G. alba* and *G. ventrolineata*. In *G. alba* the pits are very difficult to see in spirit-preserved specimens, but they are plainly enough visible in the living animal. Fig. 5 shows a ciliated pit of *G. alba* seen in optical transverse section at the lowest focus. The cells of the wall seem to be less granular than in *G. caerulea*, and the cilia do not seem to extend quite to the bottom of the pit, which appears to be occupied by a granular substance. The wall of the pit sometimes twitched spasmodically. In this species the pits are continued right round the anterior margin, and in my preparation the most anterior of them lay right on the edge, so that I was able to study them in optical longitudinal section also. Such a section is represented in Fig. 4. It will be seen that the outer part of the pit is funnel-shaped, that it is narrowest in the middle and dilated at its lower end. The cilia are largest around the external opening, and apparently absent from the dilatation at the bottom of the pit. The cells lining the lower portion of the pit could not be made out, it being necessary to focus through a considerable thickness of granular tissue.

In *G. ventrolineata* the ciliated pits have the same appearance in optical transverse section as in *G. alba*.

I next wished, if possible, to verify the observations recorded above by means of sections. For this purpose I selected a specimen of *G. ventrolineata*, in which the pits

* "Anatomy of an Australian Land Planarian."

were plainly visible after preservation in spirit (Fig. 6), and, after staining with borax carmine, cut a series of thin transverse sections across the anterior extremity by the ordinary paraffin method. I may state that, in order to ensure success, the sections must be cut as thin as possible. One of these sections is represented in Fig. 7 (the muscles, connective tissue, &c., are omitted in the figure; the nervous system, eyes, and epidermis only being shown). The light lines, in which the pits lie, are plainly recognisable in transverse sections by the comparative clearness and freedom from pigment of the epidermis and the tissues immediately below it. The epidermis also seems to be composed of shorter cells, richly ciliated. The exact position of the lines is shown in the figure (Fig. 7, *l. l.*). The pits themselves are more difficult to recognise, but the outer part of the pit is sometimes visible (provided the section be thin enough) as a depression in the epidermis, situate near the inner side of the light area (Fig. 7, *c. p.*); while sometimes the deeper part of the pit is also clearly recognisable, though not nearly so plainly as in the living animal. Sometimes, owing either to obliquity in the section or in the direction of the pit, the inner portion of the latter is cut transversely at a little distance below the epidermis. Special nerves run out from the cerebral ganglion to the light line on each side (Fig. 7, *n.*), and these doubtless supply the ciliated pits. The eyes, on the other hand, lie directly on, in fact partly imbedded in, the nerve sheath, and are apparently innervated therefrom (Fig. 7). The nerves, as usual in land planarians, appear as lighter, more transparent bands, surrounded by the more deeply staining tissues.

So far I have only described the ciliated pits as they appear in species of *Geoplana*. The only species of *Rhynchodemus* in which I have studied them is *R. simulans*, and only in spirit-preserved material. They are arranged exactly as in *Geoplana* around the margin of the horse-shoe-shaped anterior extremity, below the eyes, and a minute study of carefully prepared transverse sections, combined with microscopical examination of the anterior extremity as a whole, has failed to reveal any points of difference between the two genera in this respect.

It is impossible to be certain as to the function performed by the ciliated pits. Their position on the horse-shoe-shaped anterior margin, which, it will be remembered, is uplifted when the animal crawls, and their special innervation, indicate

that they are sense organs, and for my own part I am inclined to regard them as olfactory. They probably occur in all land Planarians, and it is not unlikely that they are homologous with the cephalic pits of Nemertines, as suggested by Professor Moseley.

DESCRIPTION OF PLATE V.

(Figures 1 to 5 were drawn from living specimens.)

FIG. 1.—*Geoplana cœrulea* (blue-tipped variety). Anterior extremity crushed flat and examined under Zeiss A, oc. 2, as a transparent object.

e.—Eye.

c. p.—Ciliated pit.

l. l.—Light line in which the ciliated pits lie.

FIG. 2.—*Geoplana cœrulea* (blue-tipped variety). Portion of the above more highly magnified. Lettering as before. The blue specks represent the pigment cells.

FIG. 3.—*Geoplana cœrulea* (blue-tipped variety). Optical transverse section of ciliated pit, surrounded by pigment cells.

FIG. 4.—*Geoplana alba*. Optical longitudinal section of a ciliated pit from the extreme anterior margin (Zeiss F, oc. 2).

ep.—Epidermis.

d.—Dilatation at the bottom of the pit.

ci.—Cilia.

FIG. 5.—*Geoplana alba*. Optical transverse section of a ciliated pit; bottom focus.

FIG. 6.—*Geoplana ventrolineata*. Enlarged view of the ventral surface of the anterior extremity of a spirit-preserved specimen (Zeiss A, oc. 2); showing the light lines and ciliated pits. The eyes are not seen, owing to the opacity of the surrounding tissues.

c. p.—Line of ciliated pits.

FIG. 7.—*Geoplana ventrolineata*. Transverse section of the specimen represented in the last figure. The nervous system is coloured blue (Zeiss A, oc. 4, camera outline).

c. g.—Cerebral ganglion.

n. s.—Nerve sheath.

n.—Nerve to light line and ciliated pits.

Other lettering as in previous figures.

FIG. 8.—*Geoplana spenceri*. Enlarged view of the side of the anterior extremity of a spirit specimen (Zeiss A, oc. 2), showing the eyes and the grooves in which the pits lie.

e.—Eyes.

gr.—Grooves.
